What is claimed is:

1. A plasma reactor for processing a workpiece, said plasma reactor comprising:

an enclosure;

a workpiece support within the enclosure facing an overlying portion of the enclosure, said workpiece support and the overlying portion of said enclosure defining a process region therebetween extending generally across the diameter of said wafer support;

said enclosure having at least first and second openings therethrough near generally opposite sides of said workpiece support;

at least one hollow conduit outside of said process region and connected to said first and second openings, providing a first torroidal path extending through said conduit and across said process region;

a first coil antenna adapted to accept RF power, and inductively coupled to the interior of said hollow conduit and capable of maintaining a plasma in said torroidal path.

2. The plasma reactor of Claim 1 wherein said hollow conduit comprises a plenum extending around the axis of symmetry of said chamber and wherein said first and second openings are comprised within a continuous opening in said enclosure extending around the axis of symmetry of said chamber.

Sub C1

2 ~~3~~. The plasma reactor of Claim 1 ~~2~~ wherein said plenum and said continuous opening extend 360 degrees around the axis of symmetry of said enclosure ~~chamber~~.

F

4. The plasma reactor of Claim 1 wherein said conduit is formed of a metal material, said conduit having an insulating gap extending transversely to said torroidal path and separating said conduit into two portions so as to prevent formation of a closed electrical path along the length of said conduit.

Sub C2

Sub C2 Cont'd

5. The plasma reactor of Claim 1 wherein said coil antenna is wound around an axis generally parallel with the axis of said closed torroidal path.

4 ~~6~~. The plasma reactor of Claim 3 ~~5~~ wherein said coil antenna comprises a first winding extending on one side of and along said conduit.

7. The plasma reactor of Claim 6 wherein said coil antenna comprises a second winding extending on an opposite side of and along said conduit.

Sub C3

8. The plasma reactor of Claim 5 wherein said coil antenna comprises a winding disposed between said conduit and said chamber.

18 ~~9~~. The plasma reactor of Claim 17 ~~8~~ wherein said winding has an outer diameter less than an inner diameter of said conduit.

10. The plasma reactor of Claim 6 further comprising at least one magnetic core extending between said chamber and said conduit in a direction generally parallel to the axis of said closed torroidal path, said first winding extending around said magnetic core.

Sub C4

21 ~~11~~. The plasma reactor of Claim 16 ~~7~~ further comprising at least one magnetic core extending between said enclosure ~~chamber~~ and said conduit in a direction generally parallel to the axis of said closed torroidal path, said first and second windings extending around said magnetic core.

F

19 ~~12~~. The plasma reactor of Claim 17 ~~8~~ further comprising at least one magnetic core extending between said enclosure ~~chamber~~ and said conduit in a direction generally parallel to the axis of said closed torroidal path, said winding extending around said magnetic core.

F

Sub C5

13. The plasma reactor of Claim 1 further comprising a closed magnetic core surrounding said conduit so as to have

Sub C5 Cont'd

one portion of the magnetic core extending through a region between said chamber and said conduit, said coil antenna being wound around said closed magnetic core.

~~14~~ 6. The plasma reactor of Claim ~~13~~ 5 wherein said closed magnetic core has a second portion outside the region between said ~~chamber~~ enclosure and said conduit, said coil antenna being wound around a section of said second portion.

F

Sub C6

15. The plasma reactor of Claim 1 further comprising:

an array of pairs of openings through said vacuum enclosure, each pair of openings near generally opposite sides of said workpiece support;

an array of generally mutually parallel hollow conduits outside of said vacuum chamber that includes said one hollow conduit, and connected to respective ones of said pairs of openings, whereby to provide respective closed torroidal paths for plasma, each of said respective closed torroidal paths extending outside of said vacuum chamber through a respective one of said array of conduits and extending inside said vacuum chamber between a respective pair of said openings across said wafer surface.

~~16~~ 23. The reactor of Claim ~~15~~ 22 further comprising an array of antenna coils, each one of said antenna coils being inductively coupled to the interior of a respective one of said array of hollow conduits and capable of maintaining a plasma current in a respective one of said closed torroidal paths.

~~17~~ 24. The reactor of Claim ~~16~~ 23 further comprising plural separately adjustable RF power sources coupled to respective ones of said array of coil antennas, whereby the plasma ion density distribution across the surface of said workpiece is adjustable through individual adjustment of said plural RF power sources.

~~18~~ 25. The reactor of Claim ~~17~~ 24 further comprising plural discrete magnetic cores confined generally to respective regions between respective ones of said array of conduits

F

and said ~~vacuum~~ enclosure, each of said array of coil antennas being wound around a respective one of said plural discrete magnetic cores.

26 ~~19~~. The reactor of Claim 22 ~~15~~ further comprising a common magnetic core extending between said array of hollow conduits and said ~~vacuum~~ enclosure, said coil antenna being wound around said common magnetic core.

F

20. The reactor of Claim 1 wherein said conduit has a width along an axis parallel with the plane of said wafer support which is at least as great as the diameter of said wafer support.

Sub C7

8 ~~21~~. The reactor of Claim 7 ~~20~~ wherein said conduit has a height along an axis perpendicular to the plane of said wafer support which is less than said width.

9 ~~22~~. The reactor of Claim 8 ~~21~~ wherein said conduit has a rectangular cross-section whereby to produce a relatively thin wide belt of plasma in said closed torroidal path.

23. The reactor of Claim 1 wherein the height of said closed torroidal path along an axis generally perpendicular to a plane of said wafer support in a process region overlying said workpiece support is less than elsewhere in said closed torroidal path, whereby to enhance the plasma ion density in said process region relative to the plasma ion density elsewhere in said closed torroidal path.

Sub C8

24. The plasma reactor of Claim 1 further comprising a conductive body between said workpiece support and said vacuum enclosure and constricting said torroidal path in a processing region overlying said wafer support.

25. The plasma reactor of Claim 24 wherein said conductive body comprises a gas distribution showerhead,

said process gas supply being coupled to the interior of said chamber through said gas distribution showerhead.

26. The plasma reactor of Claim 25 further comprising a gas inlet to said conduit connected to a source of diluent gas, said process gas supply furnishing a reactive process gas, whereby said reactive process gas is dissociated in said process region while being swept away by diluent gas in said plasma current of said torroidal path so as to reduce residence time of the reactive process gas.

27. The plasma reactor of Claim 1 further comprising an RF bias power supply coupled to said wafer support capable of maintaining a plasma sheath over a workpiece on said workpiece support of a thickness which constricts said closed torroidal path so as to enhance plasma ion density in a process region overlying said workpiece support.

Sub C9

28. The plasma reactor of Claim 1 further comprising an RF bias power supply coupled to said wafer support.

29. The plasma reactor of Claim 28 further comprising an RF bias power source connected to said wafer support and capable of maintaining a plasma sheath over a workpiece on said workpiece support of a thickness which constricts said closed torroidal path so as to enhance plasma ion density in a process region overlying said workpiece support.

~~30~~ 10. The plasma reactor of Claim ~~21~~ 8 further comprising:

a first magnetic core extending between said conduit and said enclosure across at least a portion of a first half of said width, said coil antenna comprising a first winding surrounding said first magnetic core;

a second magnetic core extending between said conduit and said enclosure across at least a portion of a remaining half of said width, said coil antenna further comprising a second winding wound surrounding said second magnetic core.

R.126

Rules 126

31. ~~28~~. The plasma reactor of Claim 27 wherein said first and second magnetic cores are longitudinally movable toward and away from a center locus overlying a center of said wafer support, whereby to enable adjustment of plasma ion density near the center of said workpiece support relative to plasma ion density near a periphery of said wafer support.

Sub B1

R.126

32 ~~29~~. The plasma reactor of Claim 27 wherein said first and second windings are closely wound around said first and second magnetic cores respectively.

R.126

12 ~~33~~ ~~30~~. The plasma reactor of Claim ~~28~~ ~~31~~ 11 wherein said first and second windings comprise a continuous winding having first and second portions around said first and second magnetic cores respectively.

R.126

~~13~~ 34 ~~31~~. The plasma reactor of Claim 1 wherein said vacuum enclosure comprises a longitudinal side wall and an overlying lateral ceiling, and wherein said first and second openings extend through said ceiling.

R.126

35 ~~32~~. The plasma reactor of Claim 1 wherein said vacuum enclosure comprises a longitudinal side wall and an overlying lateral ceiling, and wherein said first and second openings extend through said side wall.

Sub C10

R.126

36 ~~33~~. The reactor of Claim 1 wherein said conduit is elongate and tubular of a cross-sectional shape that is one of curved or rectangular, said first and second openings mating with respective ends of said conduit.

R.126

14 ~~37~~ ~~34~~. The reactor of Claim ~~33~~ ~~30~~ 10 wherein said conduit has a smaller cross-sectional area at an intermediate portion thereof than at its ends.

add E1